WaterSense® Water Budget Approach and Tool

I. Introduction

On May 22, 2008, EPA released a draft specification for water-efficient single-family new homes (www.epa.gov/watersense/specs/homes.htm). To meet the Landscape Design Criteria (Section 4.1.1), the builder may choose to comply with one of the following options:

> Option 1 – Turf shall not exceed 40 percent of the landscapable area. Turf shall not be installed on slopes greater than 4:1.
>
> Option 2 – Develop the landscape design using a water budget approach. The evapotranspiration (ET) limit on the landscapable area shall be no more than 60 percent of the reference ET (ET_o). For purposes of the ET calculation, the available rainfall shall be no more than 25 percent of the average annual rainfall amount. Turf shall not be installed on slopes greater than 4:1.

If the builder chooses Option 2, the water budget approach, the water budget calculations must be documented and submitted as part of the inspection package. To aid in the development of landscape water budget and make a complex calculation more straightforward, EPA has developed a tool to guide the builder, landscape professional, or irrigation partner through the water budget calculations. This document provides an overview of the tool as well as detailed instructions for using the tool. Definitions of technical terms are provided at the end of the document.

This tool is based upon accepted methodology developed by the irrigation industry and is laid out in a simple format for ease of use. The methodology is based upon the Irrigation Association (IA) publication, "Landscape Irrigation Scheduling and Water Management," published in March 2005.

The water budget approach allows the builder/landscape professional to design a sustainable landscape using a specified amount of water. A water budget is a site-specific method of calculating an allowable amount of water to be used by the landscape and then designing the landscape to meet this budget. The budget takes into account plant type and plant water needs, irrigation system efficiencies, and all applied water that the landscape receives either by irrigation or by precipitation, as described in detail below.

For the draft specification's Option 2 approach to landscape design, WaterSense has set a water budget (or allowance) for the designed landscape at 60 percent of the water requirement for a similarly sized landscape consisting of vegetation at the local reference evapotranspiration (ET_o), or, specifically, the amount of water required by a landscape consisting of cool-season grass of a uniform height of 12 centimeters, actively growing, completely shading the ground, and not short of water (FAO 1998 and ASCE 1990 in IA 2005). The water budget approach will allow landscape designers to plant a mixture of high-, medium-, and low-water-using plants, lending flexibility in the design of the water-efficient landscape. Budgeting for 60 percent of local ET_o does not mean that each hydrozone of the designed landscape can only receive 60

percent of the water the plants need. It means that the designed landscape, as a whole, can only require 60 percent of the water the same size landscape would require if watered at 100 percent of ET_o. This allows the landscape designer to use a combination of plants to meet this criteria.

II. The Water Budget Tool

The tool (file name: WaterSense Water Budget Tool.xls) is provided in an Excel spreadsheet format that guides the user through the water budget calculation in three parts. First, the tool calculates the amount of water the designed landscape is allowed based on EPA criteria (Part 1 – Landscape Water Allowance). Next, the tool calculates how much water the designed landscape requires based on climate, plant type, and irrigation system efficiency (Part 2 – Landscape Water Requirement). Last, the tool compares the allowable amount of water from Part 1 to the required amount of water from Part 2 and determines whether the designed landscape meets the budgeted amount (Part 3 – Results). In other words, does the landscape design meet EPA's criteria?

The rest of this document is broken down into "Background on the Calculations" and "Detailed Instructions." The background section describes the equations and information about the calculations being used in each part of the tool. The detailed instructions provide the user with detailed directions, guiding the user through the tool step by step.

General Instructions**:** Review the "Background on the Calculations" section first and then follow the directions included in the "Detailed Instructions" section. Please note, the tool only allows information to be entered in white cells. Note that each part is formatted in an identical fashion:

- The blue box at the top displays the user, builder, and site information. Once the information is entered for Part 1, it is automatically populated on Part 2 and Part 3 of the tool.
- The yellow box displays the equation that is used in the worksheet.
- The gray box is the area of the worksheet where the user enters the required data.
- The green box displays the output.

When all of the information has been entered into the tool and the water budget is complete, print the results tab (Part 3) and submit it to the builder to be included in the inspection documentation. This documentation must be provided to the builder prior to a home being inspected for compliance with WaterSense criteria.

A. Background on the Calculations

The following sections describe the equations and calculations used by the tool to complete the water budget and determine if the design landscape meets EPA criteria.

Part 1: Determining the Landscape Water Allowance

The Landscape Water Allowance (LWA) is the amount of irrigation water that WaterSense is specifying for designing a water-efficient landscape. The LWA is based on the local

reference evapotranspiration (ET_o), a water adjustment factor (K_{wa}), and the area (A) of the designed landscape (IA 2005):

Equation A-1: Landscape Water Allowance

$$LWA = \frac{ET_o \times K_{wa} \times A}{C_u}$$

Where:
LWA = Landscape water allowance (gallons/year)
ET_o = Grass reference evapotranspiration (inches/year), location specific
K_{wa} = Water adjustment factor (dimensionless), 0.60 (60 percent) for the WaterSense specification (see equation A-2 below)
A = Area of the landscape (square feet)
C_u = Conversion factor (1.6043 for results in gallons/year)

Further explanation of the water adjustment factor (K_{wa}): The (K_{wa}) helps to determine the amount of water to be allocated to a landscape by considering the landscape coefficient and overall irrigation system efficiency (IA 2005). The landscape coefficient is the percentage of ET_o a specific plant or plant type should require. This is usually about 80 percent or 0.8 for high-water-using plants such as turf, 50 percent or 0.5 for medium-water-using plants, and 20 percent or 0.2 for low-water-using plants.

Equation A-2: Water Adjustment Factor

$$K_{wa} = \frac{K_L}{AIE}$$

Where:
K_{wa} = Water adjustment factor (dimensionless) for a particular type of landscape
K_L = Area-weighted average landscape coefficient (dimensionless) for a particular type of landscape
AIE = Average irrigation efficiency, or irrigation system efficiency (dimensionless)

The calculation supporting the WaterSense 60 percent limit is:

Equation A-3: Water Adjustment Factor (0.60 for WaterSense Specification)

$$0.60 = \frac{0.43}{0.71}$$

Where:

K_L = 0.43 This is the area weighted landscape coefficient designating a mixture of high-, medium-, and low-water-using plants.
AIE = 0.71 This is the average irrigation efficiency of today's systems as determined by the California Model Water-Efficient Landscape Ordinance (CA DWR 2008).

Part 2: Determining the Landscape Water Requirement

The Landscape Water Requirement (LWR) is the amount of irrigation water required by the designed landscape. The LWR is calculated for each hydrozone and summed to determine the LWR for the site. The LWR is based on the local reference evapotranspiration (ET_o), the landscape coefficient (K_L), the hydrozone area, the irrigation efficiency (IE) of the associated system, and the effective rainfall (R_e) (IA 2005):

Equation B-1: Landscape Water Requirement

$$LWR_H = RTM \times \left[(ET_o \times K_L) - R_e \right] \times \frac{A}{C_u}$$

Where:
LWR_H = Landscape water requirement for the hydrozone (gallons/year)
RTM = Run time multiplier, equal to 1/irrigation efficiency
ET_o = Reference evapotranspiration (inches/year), provided locally
K_L = Landscape coefficient for the type of plant in that hydrozone (dimensionless)
R_e = Effective rainfall, 25 percent of annual precipitation (R) as designated by the WaterSense specification
A = Area of the hydrozone (square feet)
C_u = Conversion factor (1.6043 for results in gallons/year)

Further explanation of the effective rainfall (R_e): As defined by the IA, the effective rainfall (R_e) is "the amount of total rain that is actually stored in the root zone" (IA 2005). IA states that for planning purposes, no more that 50 percent of monthly historical rainfall should be considered "effective" toward the future water needs of landscape plants (IA 2005). Due to patterns of increased drought frequency and no guarantee that annual rainfall will reflect historical precipitation patterns, WaterSense is limiting R_e to 25 percent of annual precipitation. This is a conservative estimate to allow for a landscape to survive on less rainfall than expected and still meet the water budget and is currently being used by the State of California in the development of its Model Water-Efficient Landscape Ordinance (CA DWR 2008).

Part 3: Results

This worksheet is used to compare the LWA to the LWR to determine if the water budget is met. If the Landscape Water Requirement is **LESS** than the Landscape Water Allowance, then the water budget criterion is met. If the Landscape Water Requirement is **GREATER** than the Landscape Water Allowance, then the landscape and/or irrigation system needs to be redesigned to use less water.

Additionally, this worksheet will calculate and display the total amount of turfgrass used in the landscape. This information is necessary for the inspector to verify that the designated amount of turf was actually installed.

B. Detailed Instructions

The following sections guide the user through the water budget tool, step by step.

Part 1: Determining the Landscape Water Allowance

1. Complete the site information in the blue box at the top of the worksheet. This information will be automatically populated in the next two parts.

2. In the gray box, complete Step 1A by entering the area (A) of the landscape in square feet. Note: For purposes of this tool, the landscapable area is defined as "The area of a site less the building area, driveways, paved walkways, impermeable decks, patios, and other structures."

3. In the gray box, complete Step 1B by entering the annual grass reference evapotranspiration (ET_o) for the city or region where the landscape is located. Location specific ET_o can be obtained from local entities such as universities, Cooperative Extension offices, or local weather station organizations.

4. The results, or output, are displayed in blue cells in the green box. The LWA is displayed in both gallons per year (gallons/year) and hundred cubic feet (hcf).

5. Move to the next tab, Part 2, to calculate the Landscape Water Requirement.

Part 2: Determining the Landscape Water Requirement

1. In the blue box, confirm that the site information is pre-populated from Step 1.

2. Complete Step 2A by entering the average annual precipitation, or rainfall, (R) in inches per year. This information can be commonly found online, for example at Web sites such as the National Climactic Data Center (hurricane.ncdc.noaa.gov/cgi-bin/HPD/HPDStats.pl) or Weather Underground (www.wunderground.com/history/).

3. Complete Step 2B by entering the required information into Table 1. This table, when completed, should represent the designed landscape (i.e., all of the landscapable area should be represented in this table). Note that the combined hydrozone/landscape feature areas should equal the total landscapable area entered in Step 1 (if not, an error message will appear in Step 3).

    a. Hydrozone/Landscape Feature Area: Enter the hydrozone or landscape feature area in square feet.

b. Plant Type or Landscape Feature: From the dropdown list, choose the plant type (i.e., ground cover, shrubs, trees, etc.) or landscape feature (i.e., mulch or non-planted area, or pool/spa or water feature) for the associated hydrozone/landscape feature area. The landscape coefficient (K_L) for the respective plant type (or landscape feature) will automatically populate in the adjacent cell. For mulch or non-planted area the K_L is assumed to be zero and no water requirement will be assigned in Table 1. For a pool/spa or water feature, the associated K_L is assumed to be that of a high water using plant such as turf and is set to be 0.80. The source data for the plant type dropdown list and associated K_L values are displayed in Table 2. These plant types and associated K_L values are based on data provided by the University of California Cooperative Extension's Leaflet 21943 (Costello 1993), also cited in IA, 2005. **Note**: Additional plant types and associated landscape coefficients can be added to Table 2 in the "[custom]" cells if specific or additional plant types are being utilized in the landscape. If additional plant types and landscape coefficients are added to Table 2, then these options will appear in the dropdown list in Table 1 as options. Landscape coefficients for common landscape plants may be attainable at local Cooperative Extensions or online. For example, The University of California's Cooperative Extension published a list of K_L data for common landscape plants in California in *The Landscape Coefficient Method and Water Use Classifications of Landscape Species III* at www.owue.water.ca.gov/docs/wucols00.pdf. If custom plant types are entered, designate whether or not the plant type is turf by choosing "Yes" or "No" from the dropdown list in the column titled, "Turf?."

c. Irrigation Type and Irrigation Efficiency (IE): Choose the type of irrigation (i.e., drip, rotor, etc) that will be installed on that hydrozone. The associated irrigation efficiency will automatically populate in the adjacent cell. The source data for the irrigation type and IE are displayed in Table 3 (IA 2005). **Note:** If the hydrozone/landscape feature area is designated as "Mulch or Other Non-Planted Area," then leave the irrigation type blank. If the hydrozone/landscape feature area is designated as "Pool/Spa or Water Feature," then set the irrigation type to fixed spray.

d. LWR_H: The LWR for the hydrozone, in gallons per year, will be displayed in this column.

4. The result, or output, is displayed in the blue cell in the green box. The LWR is displayed in gallons per year (gallons/year).

5. Move to the next tab, Part 3, to review the results of the water budget tool.

Part 3: Results

1. In the blue box, confirm that the site information is pre-populated from Step 1.

a. Note, If the total area of the hydrozone/landscape feature areas entered in Table 1 of Part 2 does not equal the total landscapable area entered in Part 1, then an error message in red text will appear requesting that Table 1 be completed.

2. In the gray box, complete Step 3A by reviewing the total area of turfgrass in the designed landscape (populated from Table 1 in Step 2B).

3. Complete Step 3B by reviewing the LWA and LWR calculated in Part 1 and Part 2 respectively. The results, or output, are displayed in the blue cells in the green box. The LWR is displayed in gallons per year (gallons/year). The percentage of turfgrass in the designed landscape is also displayed.

    a. If the blue cell displays "YES" then the water budget criterion is met (i.e., LWR<LWA). Print Part 3 and submit it to the builder to be included in the inspection documentation.

    b. If the blue cell displays "NO" then landscape and/or irrigation system adjustments need to be made in Part 2, Table 1 in Step 2B. If the amount of turfgrass is changed while making these adjustments, Step 3A in Part 3 will also need to be recalculated.

C. Definitions

Effective Rainfall (usable rainfall): The amount of total rain that is actually stored in the root zone (IA 2005). IA states that for planning purposes, no more that 50 percent of monthly historical rainfall should be considered "effective" toward the future water needs of landscape plants (IA 2005). Due to recent periods of drought and no guarantee that annual rainfall will reflect historical precipitation patterns, WaterSense is limiting R_e to 25 percent of annual precipitation. This is a conservative estimate to allow for a landscape to survive on less rainfall than expected and still meet the water budget and is currently being used by the State of California in the development of its Model Water-Efficient Landscape Ordinance (CA DWR 2008).

Hydrozone: Grouping of plants with similar water (and environmental) requirements for irrigating with one of more common station/zone valves (Weinberg and Roberts 1988 and Water Management Committee 2001 in IA 2005).

Landscape Coefficient (K_L): Coefficient used to modify reference ET, which includes species factor (K_s), density factor (K_d), and microclimate factor (K_{mc}). ($K_L = K_s \times K_d \times K_{mc}$) (Landscape 2000 in IA 2005).

Landscape Water Allowance (LWA): A volume of water allocated to the entire landscape area for some period of time. This allowance is established by the water purveyor for the purpose of ensureing adequate supply of water resources (Water Management Committee 2001 in IA 2005). Also see water adjustment factor.

Landscape Water Requirement (LWR): A volume of water that is necessary for the landscape to be healthy and functional (Water Management Committee 2001 in IA 2005).

Landscapable Area: The area of a site less the building area, driveways, paved walkways, and other structures, such as impermeable decks and patios (WaterSense 2008).

Reference Evapotranspiration (Grass Reference Evapotranspiration) (ET_o): Rate of evapotranspiration from an extensive surface of cool-season grass cover of uniform height of 12 cm, actively growing, completely shading the ground, and not short of water (FAO 1998 and ASCE 1990 in IA 2005).

Run Time Multiplier (RTM): Factor used to increase zone run time to account for lack of distribution uniformity within the root zone (Water Management Committee 2001 in IA 2005).

Water Adjustment Factor (K_{wa}): A factor used to compute a landscape water allowance. This factor is based on a landscape coefficient and an expected irrigation system efficiency (Water Management Committee 2001 in IA 2005). Also see landscape water allowance.

Water Budget: A water budget is used to calculate the amount of water a landscape needs taking into account the inputs and outputs of water to and from the root zone. Inputs, such as precipitation, are subtracted from outputs, such as evapotranspiration, to calculate the water needs of the landscape. Many factors are taken into consideration when calculating a water budget, such as plant type and irrigation system efficiencies (WaterSense 2008).

D. References

Costello, et al. 1993. Leaflet 21945. University of California Cooperative Extension.

California Department of Water Resources. 2008. Model Water-Efficient Landscape Ordinance.

Irrigation Association (IA). 2005. Landscape Irrigation Scheduling and Water Management. [*Currently out for review*]

WaterSense. 2008. Draft Water-Efficient Single-Family New Home Specification.